July 2021

River Tapi Rejuvenation: Elevating the Ecological Corridor of Surat City

KINJAL DESAI
University of Massachusetts Amherst

RIVER TAPI REJUVENATION:
ELEVATING THE ECOLOGICAL CORRIDOR OF SURAT CITY

A Thesis Presented

by

KINJAL MANISH DESAI

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

MASTER OF LANDSCAPE ARCHITECTURE

May 2021

Department of Landscape Architecture and Regional Planning

RIVER TAPI REJUVENATION:

ELEVATING THE ECOLOGICAL CORRIDOR OF SURAT CITY

A Thesis Presented

by

Kinjal Manish Desai

Approved as to style and content by:

_____
Carey Clouse, Chair

_____
Samantha Solano, Chair

_____
Ranu Singh, Reader

_____
Robert Ryan, Department Chair
Department of Landscape Architecture and
Regional Planning

DEDICATION

For my parents, Sheetal - Manish and Paulomi - Chetan, and the resilient city of Surat.

ACKNOWLEDGMENTS

I would like to express my deepest gratitude and appreciation to my committee members, Prof. Carey Clouse, Prof. Samantha Solano and Ranu Singh who expertly guided me through my research and thesis. Their overwhelming interest, scholarly and timely advice, persistent help and motivation have made this thesis possible.

My appreciation also extends to the Umass, Amherst LARP department for providing me with an opportunity and resources to achieve the completion of this thesis. I would also like to thank Kellie Nicholas for supporting me and patiently helping me throughout the process.

I owe a deep sense of gratitude to Mr. Kamlesh Yagnik, who helped me ground truth this thesis and encouraged me to critically think it through and beyond. I profusely thank Mr.Rajesh Desai, Prof. Niraj Naik, Niyati Desai, and members of Surat city GIS cell for their kind help and co-operation during my research.

I am indebted to my family for their constant encouragement and source of inspiration. It is my privilege to thank my partner Mitra who has been a motivating force through my journey.

Lastly, I would like to thank with humbleness to all those who supported me and helped me during this thesis.

ABSTRACT

RIVER TAPI REJUVENATION:

ELEVATING THE ECOLOGICAL CORRIDOR OF SURAT CITY

MAY 2021

KINJAL MANISH DESAI

B.ARCH., FACULTY OF ARCHITECTURE, S.C.E.T., INDIA

M.L.A., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Professor Carey Clouse

With rapid urban sprawl, comes new challenges to the trends in urbanization. The recent trends in urban development bring urban systems and urban experiences into daily contact with natural habitats. So, it is extremely important to consider natural systems in play while designing for an Urban ecosystem, which is one of the principles of Landscape Urbanism. It is a design practice that intervenes Natural landscape and habitation to form an integrative systems approach. This thesis is built upon approaching an urban riverfront development project through the perspective of Landscape Urbanism. It aims at developing design strategies for the ecological restoration of River Tapi and an environmentally efficient riverfront.

The site context is carefully studied and analyzed through literature review, history, mapping analysis, public survey, on site observation and activity mapping. The complex concerns that emerge out of context study are strategically organized as a

system of categories. Building upon these categories, are design interventions to combat those. These interventions are then validated through a prototype site design which can be used as a module to further rejuvenate River Tapi and develop the riverfront.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

"Surat city is going to be the next Chicago, Mumbai is going to be the next New York" Phrases like this are often heard while talking about urban development of cities in developing countries. It suggests that attimes the urban trends in developing countries are directly influenced by developed countries. This overlooks the complex context of developing countries like social philosophies, culture, the unsaid rules and norms and the by laws, but it also provides an opportunity to experiment with the knowledge and experience of developed countries and vibrant context of developing countries. Recently, researchers and designers have begun to use landscape urbanism as a model of Urbanization. It integrates Naturals and cultural systems to dictate the flow of urban landscapes. While much research and literature is available for developed countries, little has been known about Landscape Urbanism in developing countries. This thesis attempts at understanding the application of landscape urbanism principle for developing Tapi riverfront located in Surat, Gujarat, India (Refer to fig.1).

The research undertakes an in depth contextual study through history, mapping analysis, public survey and on site observation to understand the complex concerns and threats to the ecological corridor of Surat city. How can the complexity of these concerns be addressed systematically? The research also aims to understand the various systems in play. What are the points of intervention that can address the complexity of the site? And how can a prototype design elevate the amenity of Surat city by integrating the complex systems in play?

Metro area	326 square kilometers (126 square miles)
Population	7,185,000
Population Density	14,000 people per square kilometer (35,000 residents per square mile)

Fig 1. Location of Surat city

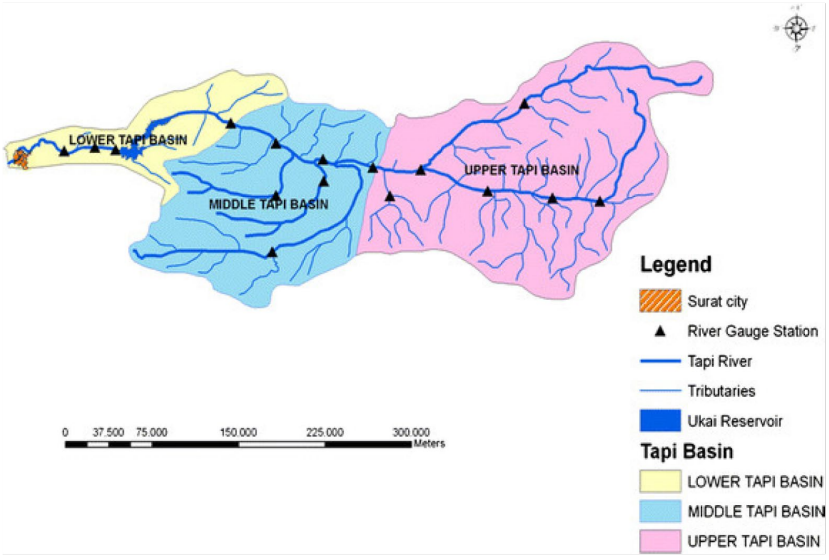

Fig 2. River Tapi Watershed

CHAPTER 2

LITERATURE REVIEW

2.1 Landscape Urbanism

Urbanization is an important component of global land transformation. The cities sprawling into the agricultural and forest lands interfere with the natural systems of wildland. It has subsequent effects on regional landscapes. The new trends in urban development bring urban systems and urban experiences into daily contact with natural habitats. Urban habitats leave an open frontier for integrating ecological systems into new planning and design tools. This approach of developing urban landscapes dictated by cultural and natural processes is Landscape Urbanism.

This thesis builds on the principle of Landscape Urbanism as a design practice that intervenes Natural landscape and habitation to form an integrative systems approach. It allows the curves of landscape to self proclaim its transformation and guide the urbanization of the city. The integrative systems approach looks at the relationships and interactions between parts, seeking to devise solutions that are integrative. The reductionist approach of traditional space making often has unintended and unexpected impacts as they are focused on one part of the system only. So, What are these integrative systems?

The integrative Ecosystem approach offers benefits to all living beings, humans, animals and plants. It provides resource services such as climate regulation, waste decomposition, food, water, crop pollination and purification of water; support services

such as dispersal of nutrients; cultural services, ecotourism, recreational experiences, and habitat for native biodiversity.

Smaller patches of ecosystem services act as a part of patch dynamics for regional ecological systems. This provides continuous ecological corridors for species to migrate and are crucial for their survival. It also helps the urban ecosystem by reducing heat island effect, carbon sequestration, water filtration, and reducing global warming. With an increase in global urbanization, the planning and design trends need a new perspective which is the systems perspective to coexist with Nature.

A city where the green open space ratio is low compared to the high population density and urban sprawl, Natural ecological corridors like River Tapi are opportunities for rejuvenation and development using the system's lens. By elevating the ecological corridor of the city, the thesis aims at rejuvenating the lost ecosystem, enhancing community engagement with nature and develop an environmentally efficient riverfront.

2.2 Surat City & River Tapi

2.2.1. History

Timeline

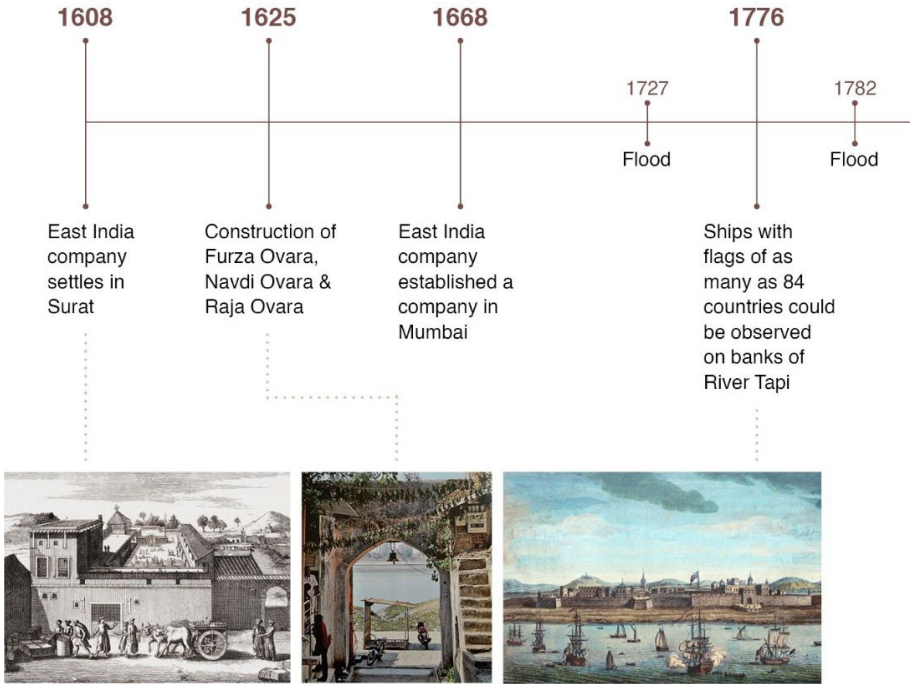

Fig 3.1 Historical Timeline

Surat; It was here that the East India company first settled in as traders in 1608. The city was a hub for trade and business because of its geographical conditions; mainly ports of River Tapi and the Dumas beach. Around 1625, three major Ovaras (Ports) were constructed namely Furza Ovara, Raja Ovara and Navdi Ovara. Functionally, Furza ovara was the customs checkpoint of those times. A huge metal bell hanging at the gate announces each new incoming ship. Raja Ovara was exclusively for royalty and their commodities, while Navdi Ovara was mainly used by Dutchmen for loading and unloading of their factory goods. In 1668, the East India Company established a company in Mumbai and slowly a decline in trade began. Until 1776 ships with flags of as many as

84 countries were observed on the banks of River Tapi. With English East India Company, Armenian merchants, French seaman and the Dutch Masters of maritime trade, the city and its culture was known worldwide prior to the establishment of metro cities in India.

Infrastructure History Timeline

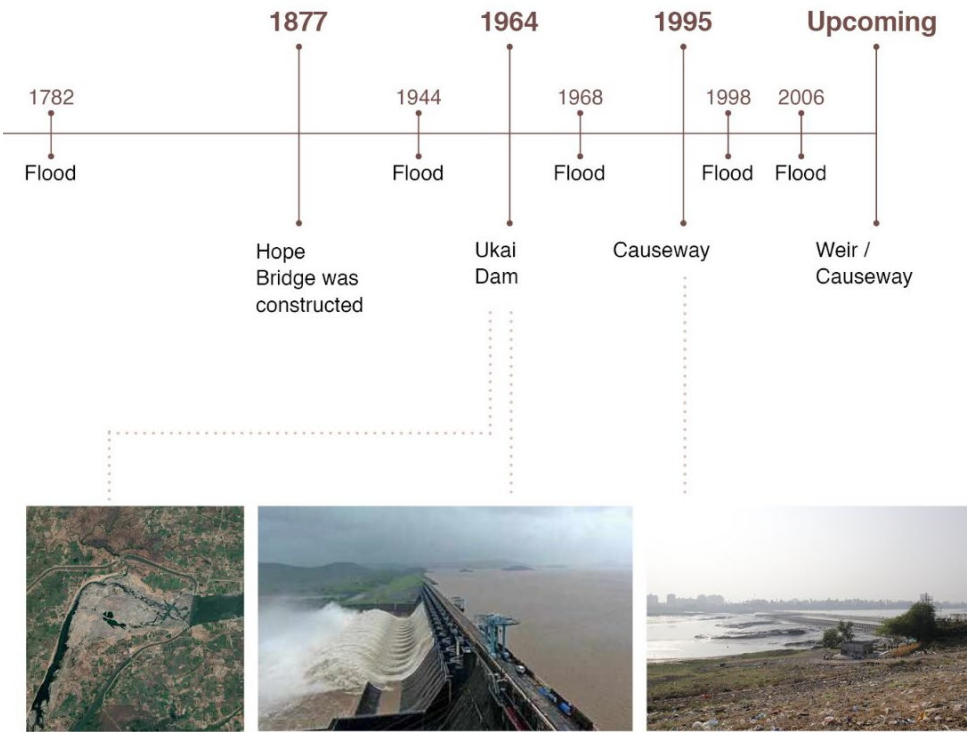

Fig 3.2 Infrastructure History Timeline

Moving forward in time, in 1877, the first ever bridge, Hope Bridge, was constructed across River Tapi to connect two sides for a better commute network. Before reaching the city and Hope bridge, the river passes through two major dams, Ukai Dam and Causeway built in 1964 and 1995 respectively. Tapi has been known for notoriously changing its course and with the intervention of these two dams its natural ecological flow has suffered quite a lot. As observed from the timeline, one of the major side effects

of dams is the chances of flooding have increased significantly in recent times. Moreover, there are future plans to build an additional dam for the city's upcoming riverfront project. These could disrupt the river's flow into the sea and the coastal beaches causing harm to the natural biodiversity, ecosystems and one of the city's greatest amenity, its River.

Evolution of Surat City and River Tapi

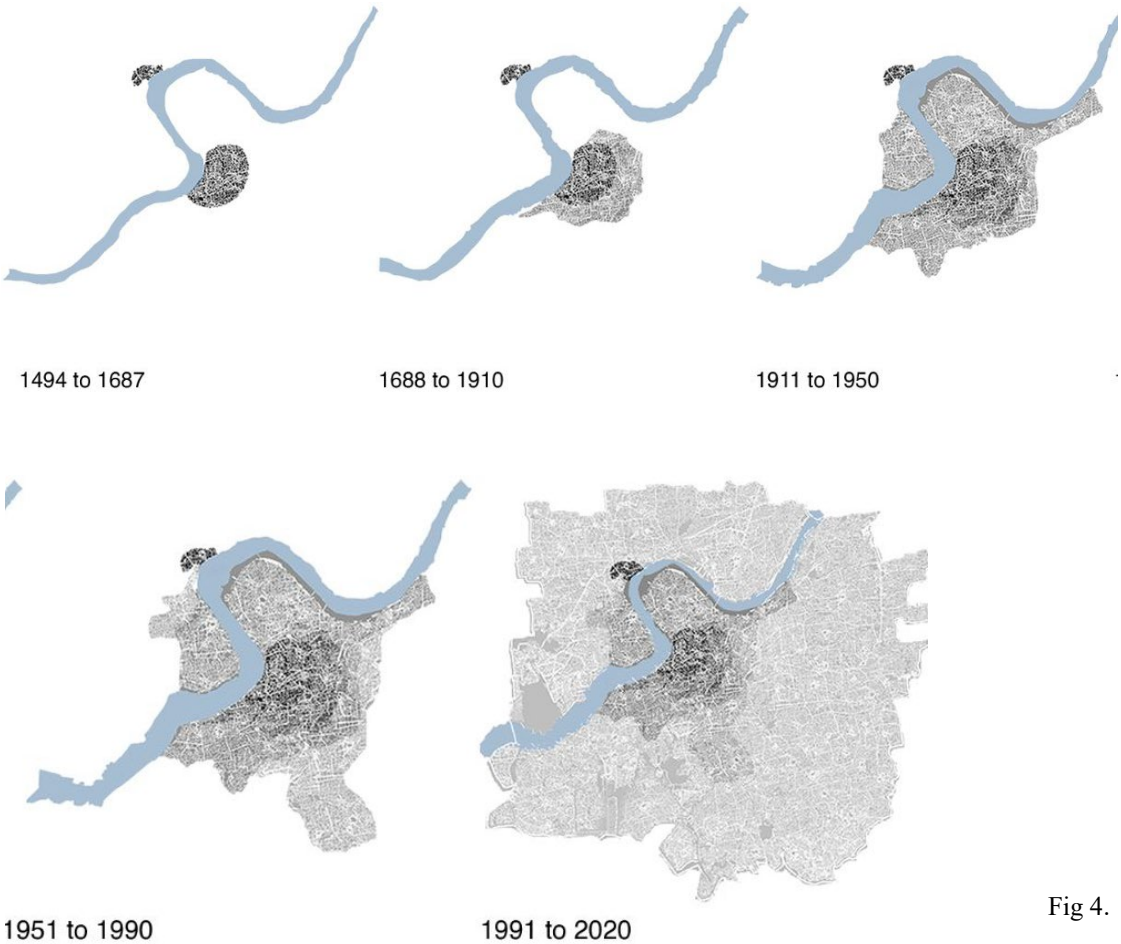

Fig 4.

Evolution of surat city

Due to its history of sea trade and business, the city started developing around the fertile lands of River Tapi. It has since sprawled in a radially outward direction. As seen

in the successive diagrams above, the connection between city and river has been a dynamic one and has enhanced over the period of time. While there are cons, this connection is also an opportunity for amalgamation of Nature, Community and the City.

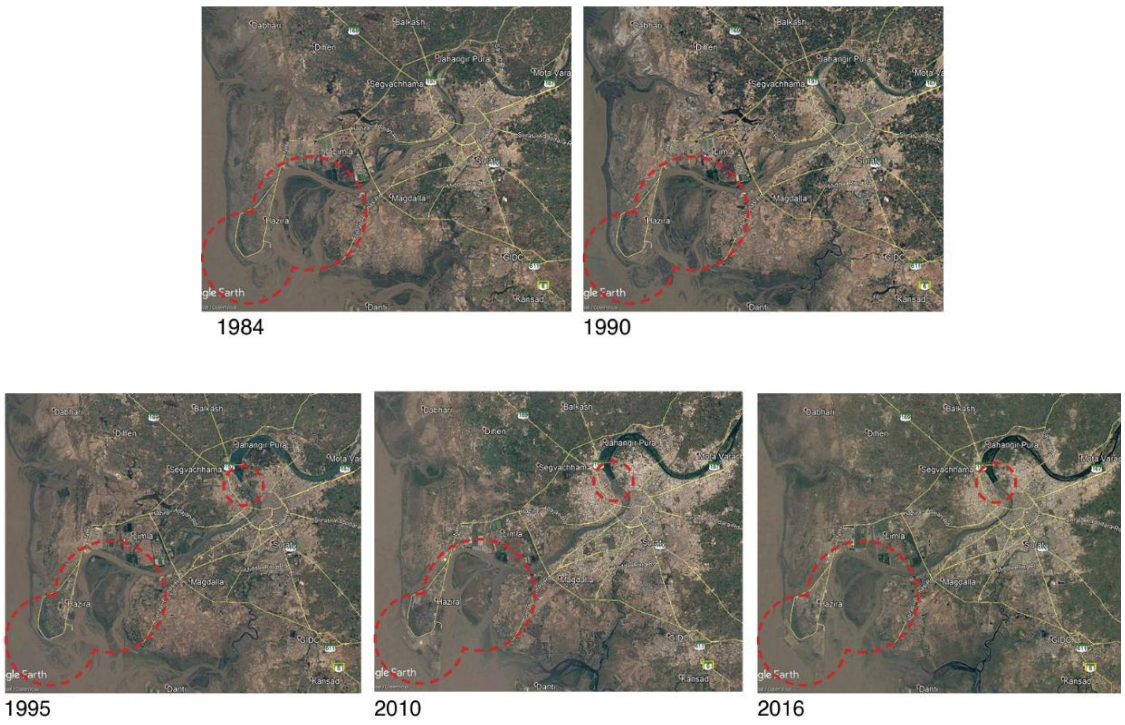

Fig 5. Evolution of River Tapi

From 1984 to 2020, there have been significant modifications in the course of River Tapi. The estuary has been modified due to landfills by nearby companies, which intervenes with the flow of river into the sea. As noted in history, the causeway constructed in 1995 narrows the flow of water downstream. These are the two major threats to River Tapi that need to be addressed immediately for its conservation and development of an environmentally efficient riverfront.

2.2.2. Biodiversity

Fig 6.1 Native Biodiversity; plants

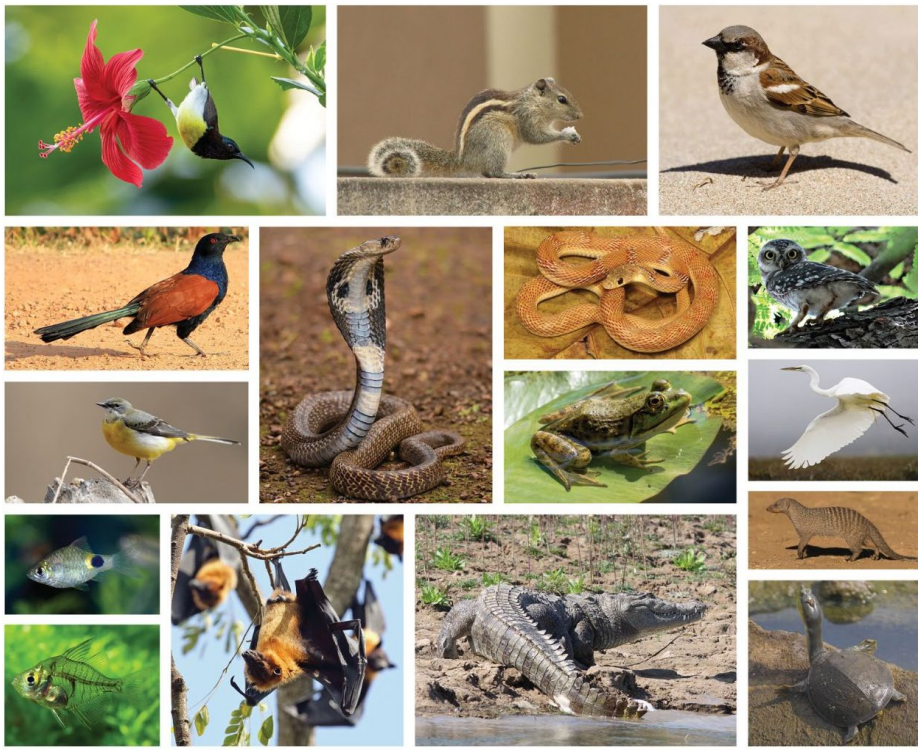

Fig 6.2 Native Biodiversity; animal species

If you have a small garden at a house in Surat city, it is possible that one witnesses at least 10 different species of birds. From sparrows to peacocks dancing in the monsoon, a chameleon to a snake and a couple of mongoose roaming around, the local biodiversity is very intriguing and vast. But, in recent years, the region has experienced loss of its Native biodiversity due to large-scale landscape remodification, exploitation of resources and human intervention. In Gujarat, 20 animal species and 16 plant species are in endangered category (Desh Gujarat, magazine, 2019), Sparrow population has fallen by 20% (Indian Council of Agricultural Research (ICAR), 2020) and Great Indian bustards (GIB) population fell by 90% (TOI, 2019). These alarming numbers call for an urgent conservation effort to protect the biodiversity of the city.

2.3 People and Culture

River Tapi and People of Surat city share a deep connection from celebrating cultural festivals, religious ceremonies, sacred offerings and fertile lands for production.

Fig 7. People and Culture

River Tapi is considered holy just like the Ganges, hence people worship the river and even celebrate its birthday by following the traditions and rituals. (But, do we really take care of it like a holy river?) During some festivals it becomes a prime spot for public gatherings and celebrations. In Uttrayan, the kite flying festival is a great tourist attraction where people gather on the Tapi riverfront to enjoy the occasion. The sky is filled with creativity and the ground with skilled artists. In Ganesh Chaturthi, people gather by offering huge idols of lord Ganesha to the holy river for its final rituals. While flowers and rice offered during these rituals are a source of food for aquatic life, materials like plaster of paris and toxic chemicals are harmful for the health of the aquatic ecosystem.

Moreover, the fertile lands of River Tapi are great for agriculture. Many farmers rely on these lands for crop production and celebrate their harvest. During the seasons, when the floodplain of the river dries out, it functions dually as a seasonal market. In the

dense urban fabric of surat, people will find creative ways to keep up the seasonal markets and traditions.

In recent years, there has been a great attraction for water sports. New ventures offer boating, jet ski and floating restaurants. The relationship between people and river Tapi has been evolving and a well planned riverfront will add the greatest value to the culture and traditions of the community.

CHAPTER 3

SITE ANALYSIS

3.1 Mapping Analysis

As a part of this thesis, a comprehensive GIS analysis was performed to better analyze and identify the patterns and depth of factors affecting river Tapi. The data was derived from the Surat GIS cell and Esri GIS resource library.

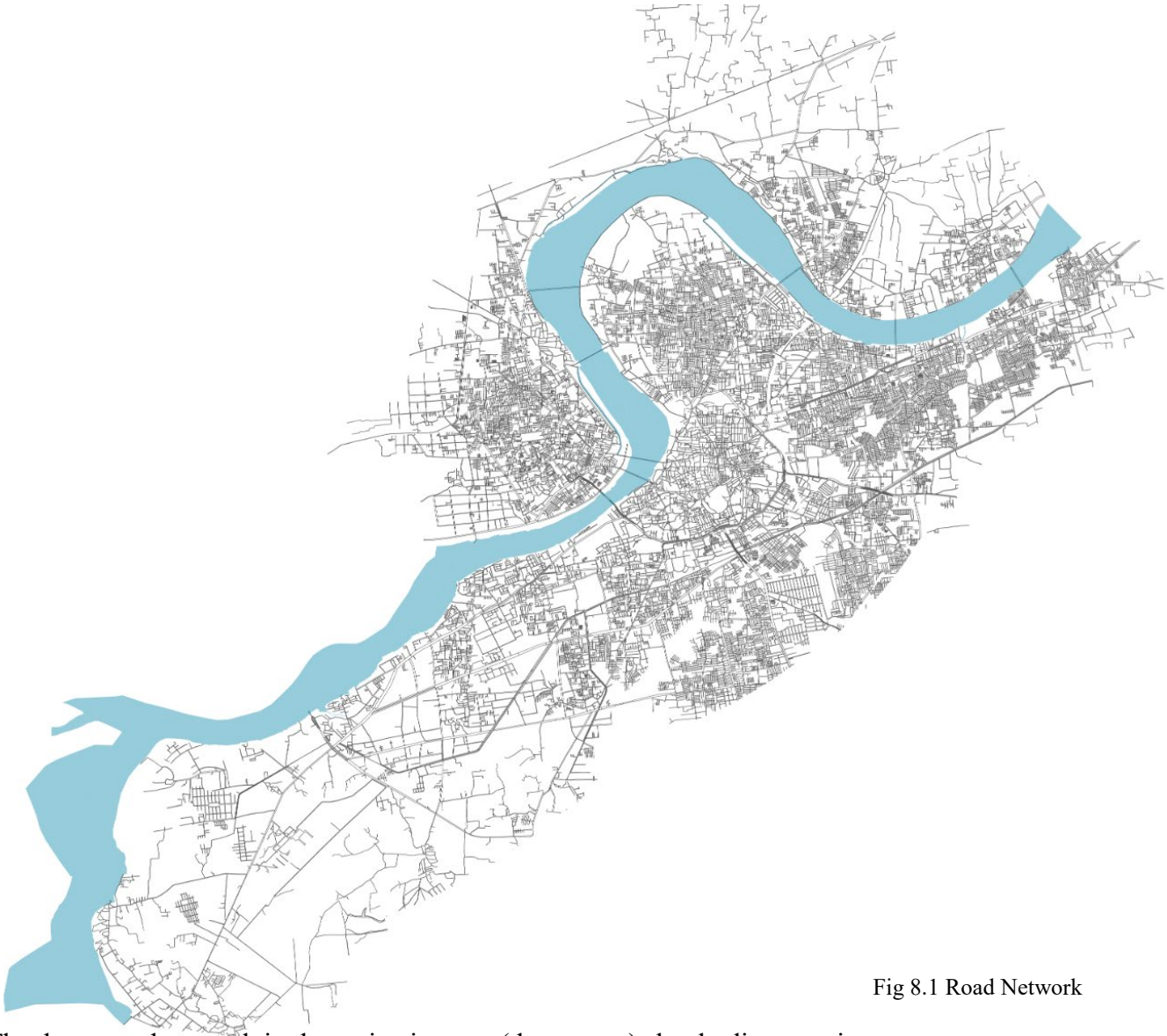

Fig 8.1 Road Network

The dense road network in the main city area (downtown) slowly disperses into a sparse network. The dense fabric accounts for more entry points to access the river.

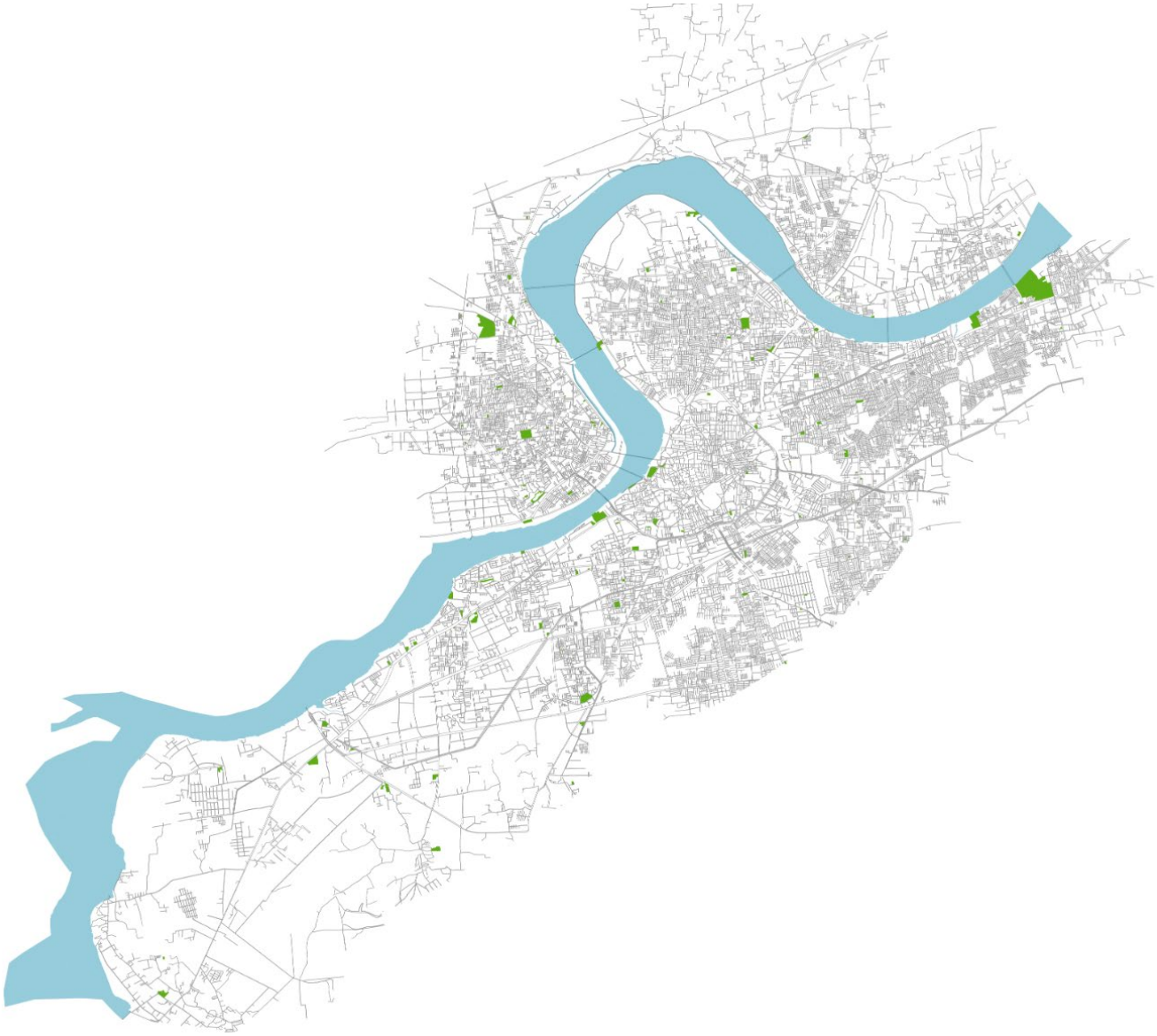

Fig 8.2 Public Parks

In a city with high population density but low green open space ratio, not all the communities have equal access to public parks.

Fig 8.3 Worship Places

Worship places are major public gathering spaces especially for age group 45+. And because of the trading history by means of waterway, most of the worship places originated on the holy banks of the river and can still be observed there.

Fig 8.4 Informal settlements

The banks of river Tapi is also a home to many informal settlements. They mostly reside on the unused barren lands and use direct river water for their functional needs.

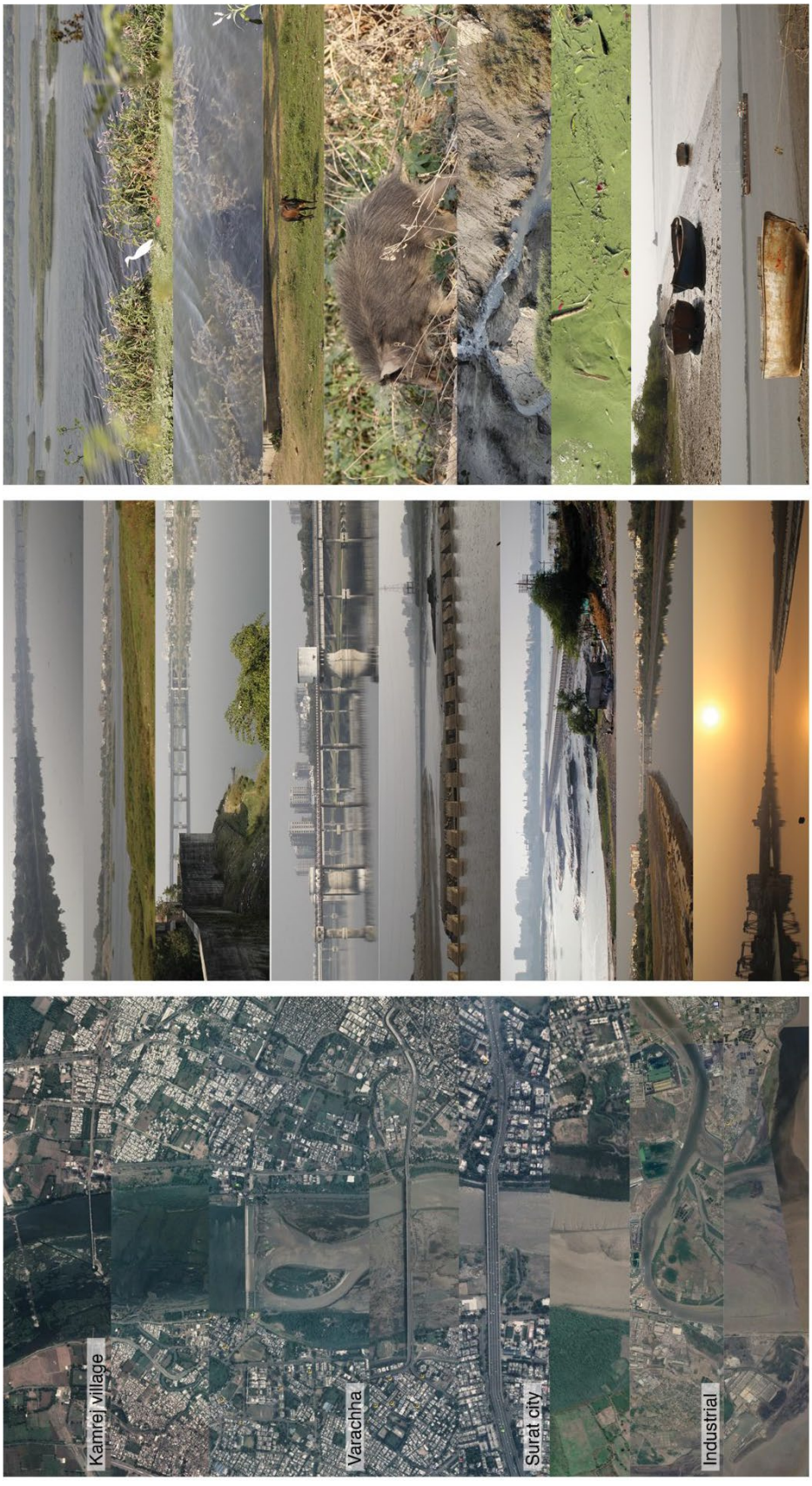

Fig 9. Journey of River Tapi

3.2 Journey of River Tapi

The picture collage narrates an anecdote of the journey of River Tapi. The course of the river starting in Kamrej village is a beautiful lush green and full of water. This landscape houses migratory birds and grazing animals creating an atmosphere of the river where everyone wants to live. It maintains a similar course until it reaches the causeway. At the causeway, stagnant water causes algae formation to an extent where the water color changes into green. The flow is then interrupted by this causeway which causes the streamflow to narrow down. Due to inadequate water flow, it is now surrounded with sludge on both sides. This landscape attracts mosquitoes and mud loving animals like pigs. By the time it reaches the main city area, the landscape color changes into brown. As the river flows further it picks on smell from unmonitored discharge. Near the estuary it flows through an industrial zone that adds to the foul and slimy smell. When it reaches the modified estuary, it has a very narrow stream flow into sea due to landfills by nearby companies.

3.3 Active Tapi Riverfront Project

The Tapi Riverfront Development and Rejuvenation Project is an initiative taken up by the Surat Municipal Corporation to develop the Tapi River (for approx. length of 33km from Kathore Bridge to ONGC Bridge) in a holistic and comprehensive manner and increase its asset value for Surat city.

Identified Issues: Risk of Flooding, Polluted River Water, Lack public amenities, Inadequate connectivity to river, Inability to retain water

Identified Opportunities: Strengthen River Edge, Clean the river, Create a continuous public realm, Improve accessibility & connectivity, Retain & replenish water

Proposed Goals: Integrate Tapi cleaning project

- Land Reclamation for recreational purposes
- Broad zoning master plan
- Emphasize several green spaces
- Development of public amenities
- Development of Continuous promenade (Pedestrian & cycling)
- Improve access to riverfront
- Improve transportation network

Upon observation, the ecological health of river Tapi has been overlooked in the identified issues, opportunities and the proposed goals. A riverfront is incomplete without a healthy river, yet it is only the development sector which is discussed in a master project. The foul smell and brown landscapes have already become a reason for people to not engage with the existing riverfront walk. The design strategies carefully consider the environmental threats to the riverscape and recommend optimal solutions to achieve ecological efficiency.

CHAPTER 4
DESIGN INTERVENTION

4.1 Concerns Analysis

Fig 10.Concerns

In developing countries like India, tangible site concerns are overlapped with intangible aspects like rituals, unsaid norms, society expectations, etc. This overlap creates a complex structure and needs strategic organization. So, this thesis initially focuses on analyzing patterns and builds upon a system of categories to address these concerns as shown in the figure below.

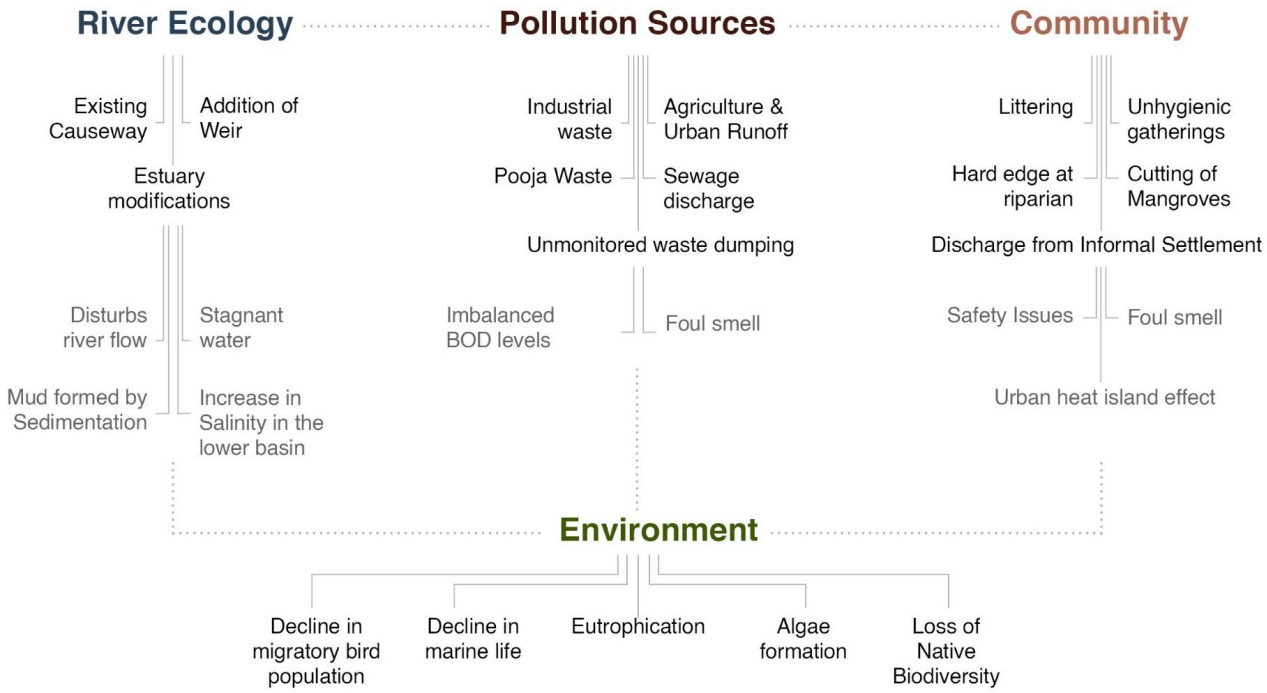

Fig 11. Concern analysis

The concerns are derived from historical study, mapping analysis, public survey and on site observation. These concerns are then categorized into three parts as River Ecology, Pollution Sources and Community. And these three categories together cause environmental concerns. Each category has identified primary sources that are responsible for the successive concern.

The primary sources of River Ecology like existing causeways, estuary modifications are responsible for the successive concerns like stagnant water, disturbs river flow, increases salinity and sedimentation. Similarly, The primary sources of Pollution like Industrial waste,Agricultural runoff, sewage discharge are responsible for imbalance bod levels and Foul smell. And The sources of Community like littering, cutting of mangroves are responsible for safety concerns and urban heat island effect.

All of these categories together causes environmental concerns of eutrophication, algae formation, loss of native biodiversity and decline in marine life and migratory bird population

4.2 Design Strategies

Building upon the categories of concerns are design strategies to combat those. The strategies consist of similar four categories. Although categorized in different ways, they are all interdependent on one another.

Fig 12. Design strategies

4.2.1. River Ecology

Projects under this category are xxxl level projects but are important for the ecological health of river tapi.

Causeway/ Dam Alternatives

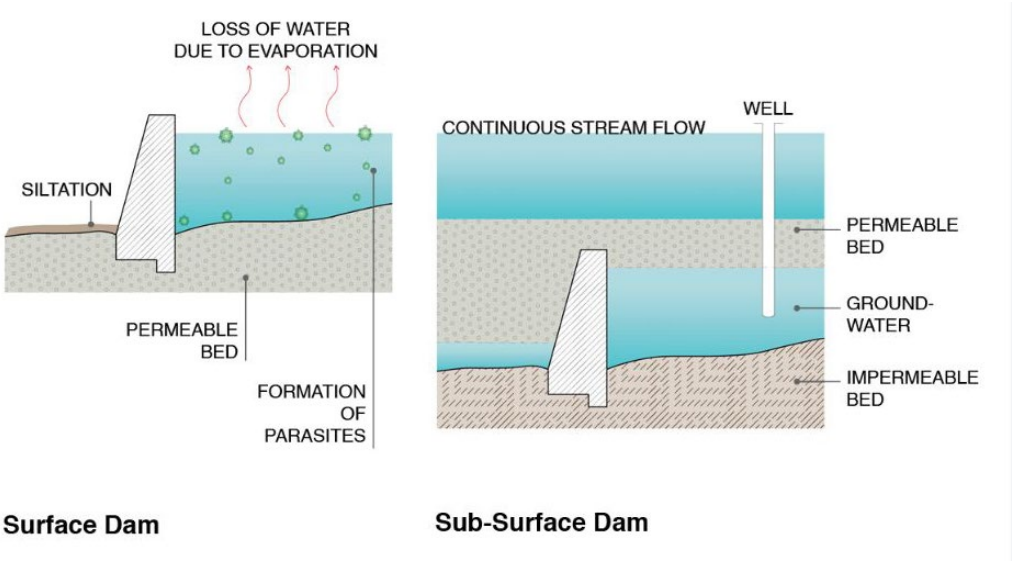

Fig 13.1 Sub-surface dam

Instead of surface dams, constructing subsurface dams to harvest ground water could be beneficial. It could avoid loss of water due to evaporation, recharge ground water and prevent formation of parasites. It would also allow for continuous streamflow at the same time meeting the growing city water needs.

Efficient alternatives to store water

Another efficient ways to store water without harming the land or habitat are:

Coastal flood water reservoir - it could also help prevent flood

Reuse of greywater - it can also be filtered naturally for use again in utilitarian purposes

Collecting stormwater at smaller and larger scales - in a tropical climate, collected stormwater could reduce stress on municipal to meet the city water needs

Estuary Re-modification

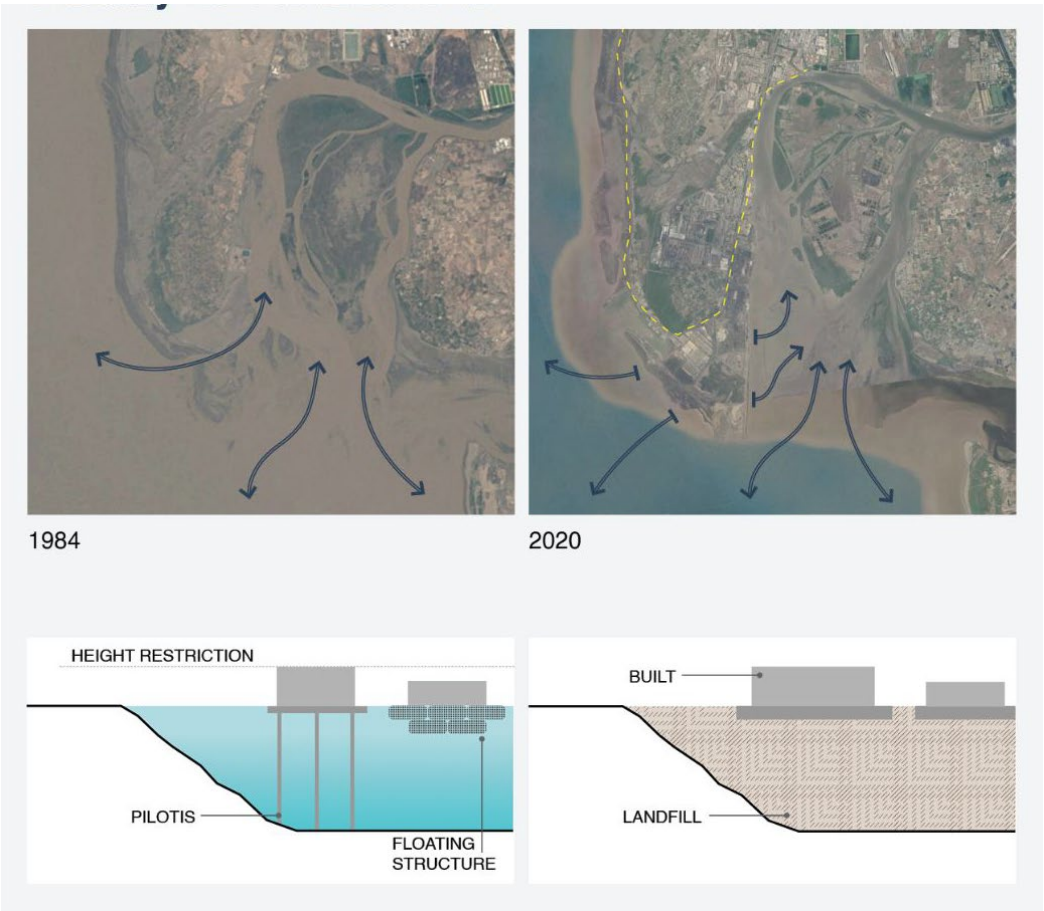

Fig 13.2 Estuary re-modification

Instead of land infill that intervenes with the river-sea water flow, surfaces standing on pilotis and floating structures could help without disturbing the flow.

Now that the environmental flow of river Tapi has been restored, do we still need a weir cum causeway to artificially store water for economy, activities and varied human needs?

4.2.2. Pollution

Tapi cleaning project

It is an existing government project that aims at district wise waste disposal design, sewage treatment plans, river monitoring and remedial measures to combat river pollution.

Industrial Waste filtration

Disposal of industrial waste should certainly be banned. A toolkit made available to the public that expands on standards of filtration process, quality of filtered water and disposal into the river could help educate and spread awareness.

Fig 14.1 Industrial waste

Festive Celebrations Alternative

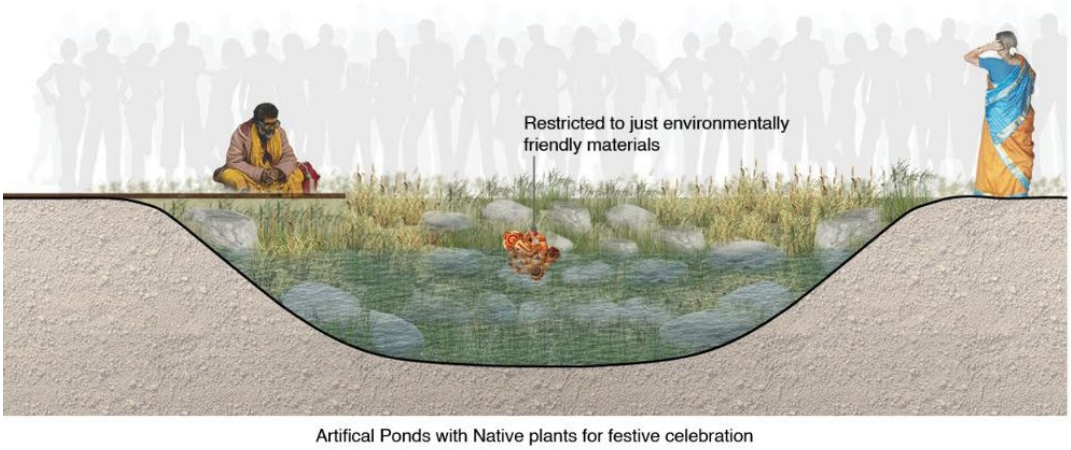

Fig 14.2 Festive celebration alternative

Artificial ponds, with native plants and permeable surfaces, that are restricted to only environmentally friendly materials could reduce pooja waste and festive pollution.

Floating wetlands

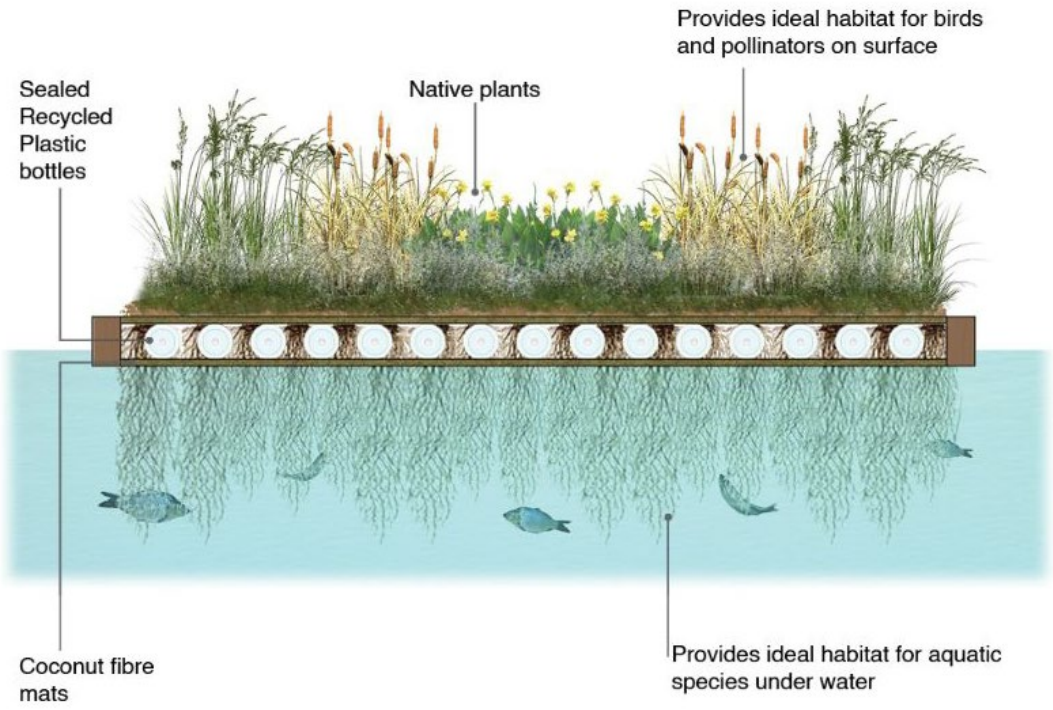

Fig 14.2 Floating wetland

Floating wetlands with native plants provides ideal habitat for birds, pollinators and aquatic species. It can work as an aquatic or migratory ecosystem-patch and bring back the lost biodiversity. It could help clean up pollution from river tapi and water of river Tapi.

4.2.3. Community

Planned Public Gatherings

Surat has a rich cultural glory and with its unique characteristic, designed public places would provide an opportunity for a planned and systematic public gathering.

It could Support local artists, Enhance the flea market experience and provide space for Seasonal markets and Temporary food stalls.

Fig 15.1 Seasonal markets and culture

River Tapi cell

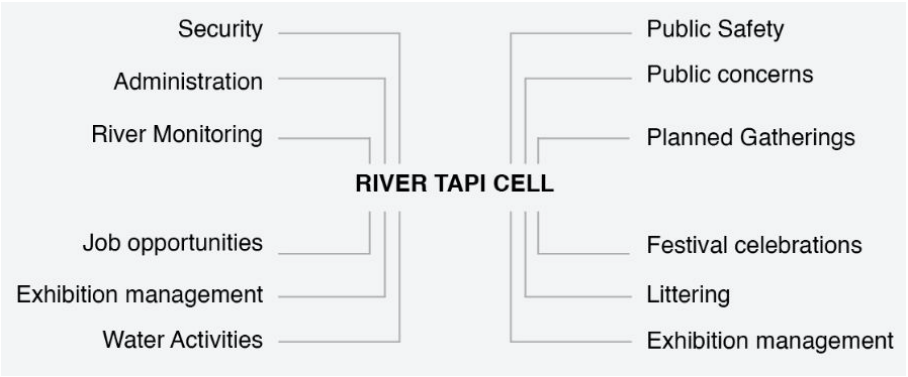

Fig 15.2 River Tapi cell

There are many organizations that perform different functions for river tapi. Instead A river tapi cell that overlooks all the operations in regards to the river like Administration,

river monitoring, seasonal market management, public safety and public concerns could elevate the river management system.

Managing Informal settlements

Previously, under government policy, a group of informal settlements were moved from Tapi riverfront to a safe public housing site for phase 1 Tapi riverfront project. Similarly, the remaining informal settlements could be safely moved to the public housing site with basic amenities of water and sewage.

Moreover, the developed riverfront could also provide employment opportunities for them.

4.2.4. Environment

Inland and Coastal Wetlands

Fig 16.1 Inland and Coastal wetland

An increase in Inland & Coastal wetlands could improve the water quality, provide protection against flood and can control shoreline erosion.

Native plants

They are important. Planting schemes should be carefully considered to include Native plants. While imported planting would look sophisticated, native plants are the powerhouse of biodiversity, require less maintenance, help fight against climate change and if designed can be aesthetically pleasing as well.

Stormwater garden

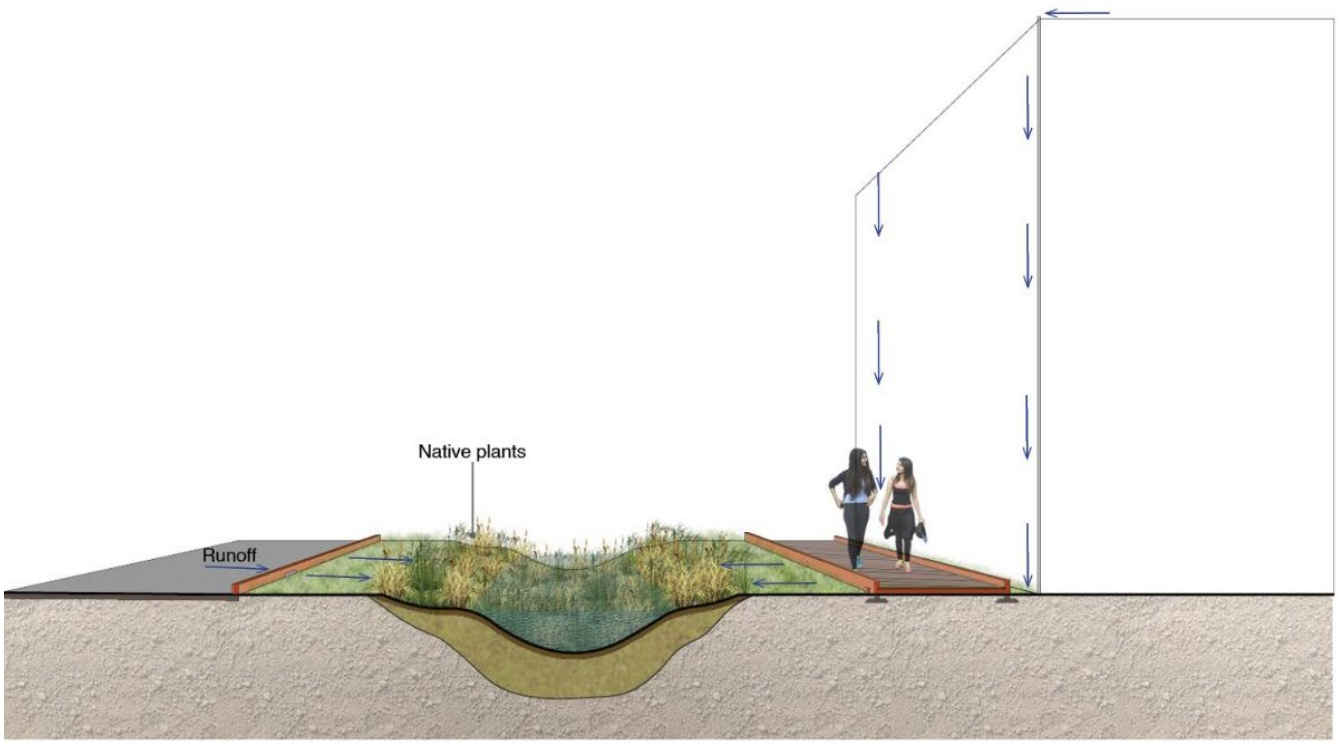

Fig 16.2 Stormwater garden

Runoff from buildings, roads and pathways could be directed into stormwater gardens, where it filters the water before disposing to the river or can be used as a rainwater

harvesting system. These will remove unwanted debri and chemicals that the runoff collects and ensure clean water disposal into the river.

These Design strategies discuss varied integrative systems for the region and are further demonstrated on a selected site along river Tapi. This site design could be used as a prototype design module for developing an environmentally efficient riverfront.

CHAPTER 5

PROTOTYPE SITE DESIGN

5.1 Site Introduction

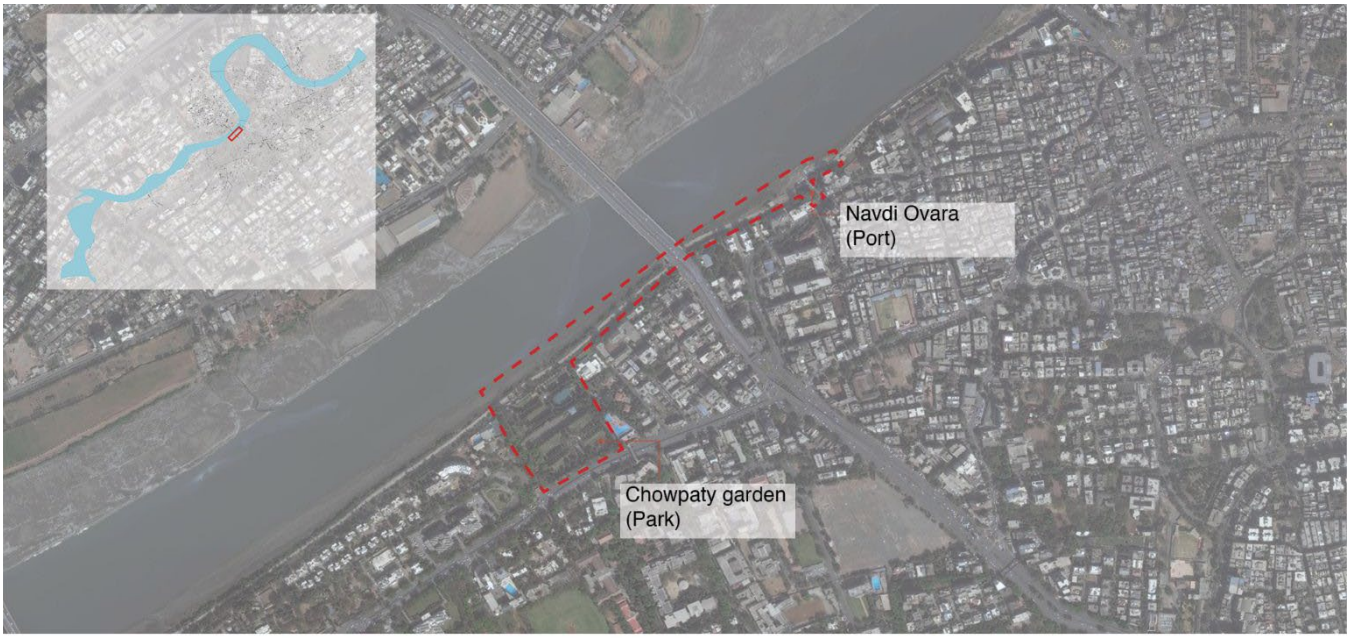

Fig 17 Prototype site location

The site, Park to Port or Port to Park is located at the transition between the old walled city and new city area. It connects two crucial sites, Navdi Ovara (Port) and Chowpaty garden (Park) through the existing riverfront walk. As noted in history, the Navdi Ovara has been an important historical node between the community, city and river. And the Chowpaty garden is one of the city's oldest public gardens that holds childhood memories for millions of residents. Recently, the site was proposed for upcoming municipal buildings, but the proposal faced refusal and rage from the activists and community. As a result, the garden was saved for now. This is an opportunity to functionally upgrade the garden in order to spark public interest and continue the legacy of providing an intriguing public park experience.

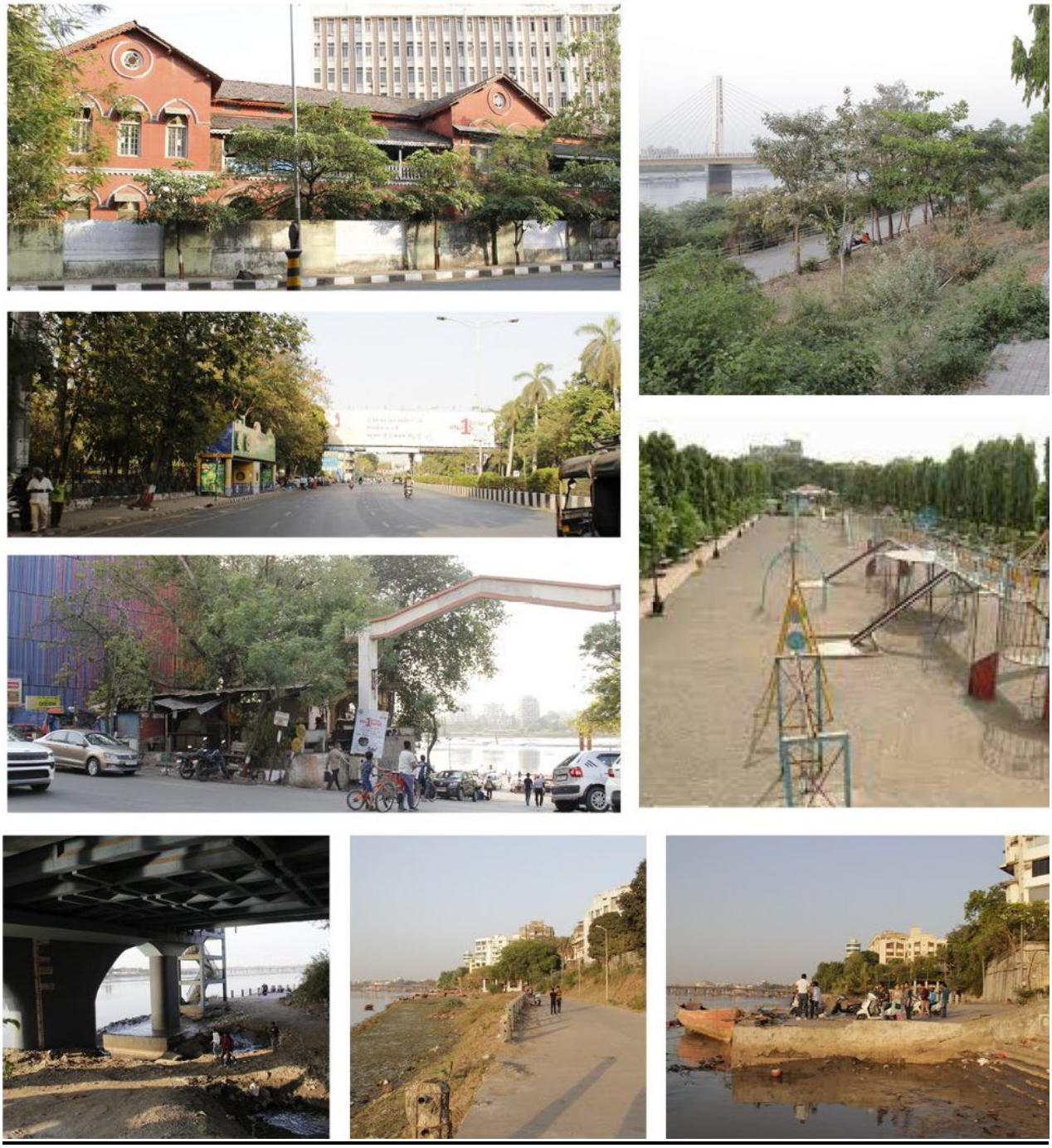

Fig 18. Prototype site character

5.2 Site Analysis

Fig 19.1 Road Network

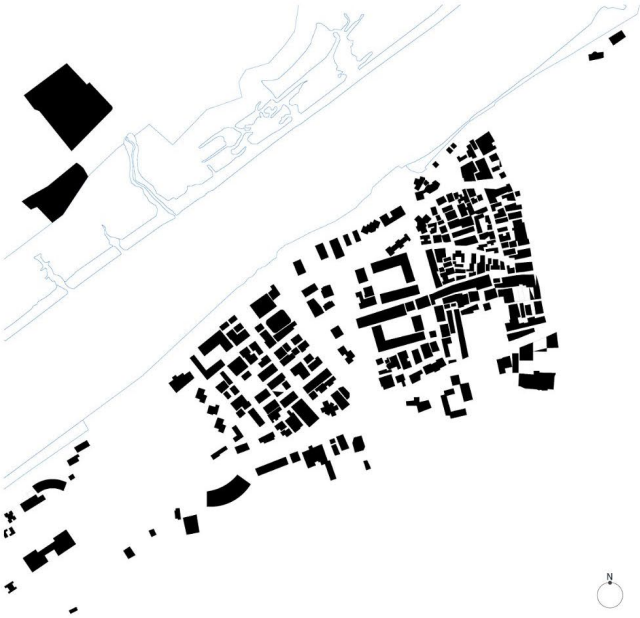

Fig 19.2 Built v/s open

Fig 19.3 Land Use

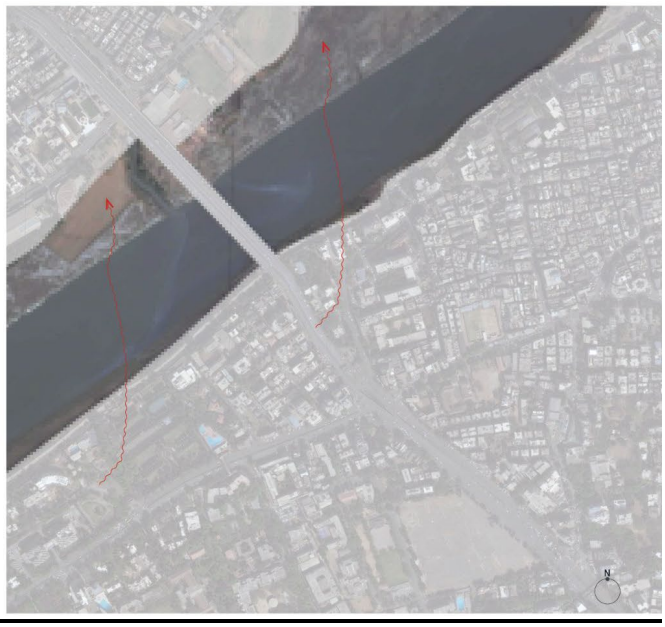

Fig 19.4 River delta

5.3 Site Design

The programming requirements for this site was derived from public survey, on site observation and activity mapping. Apart from the graph below, major suggestions for programmatic spaces included porous mobility, child play area, yoga/ meditation place, education about river Tapi and its history and safe places for socializing.

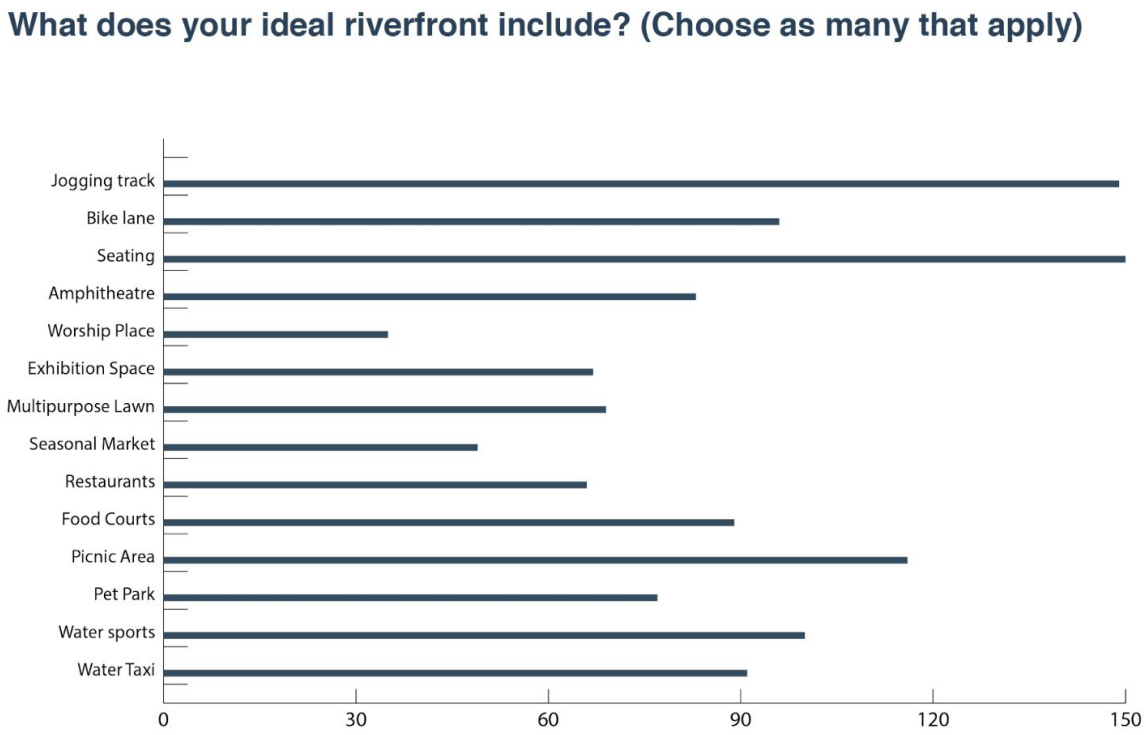

Fig 20 Public survey

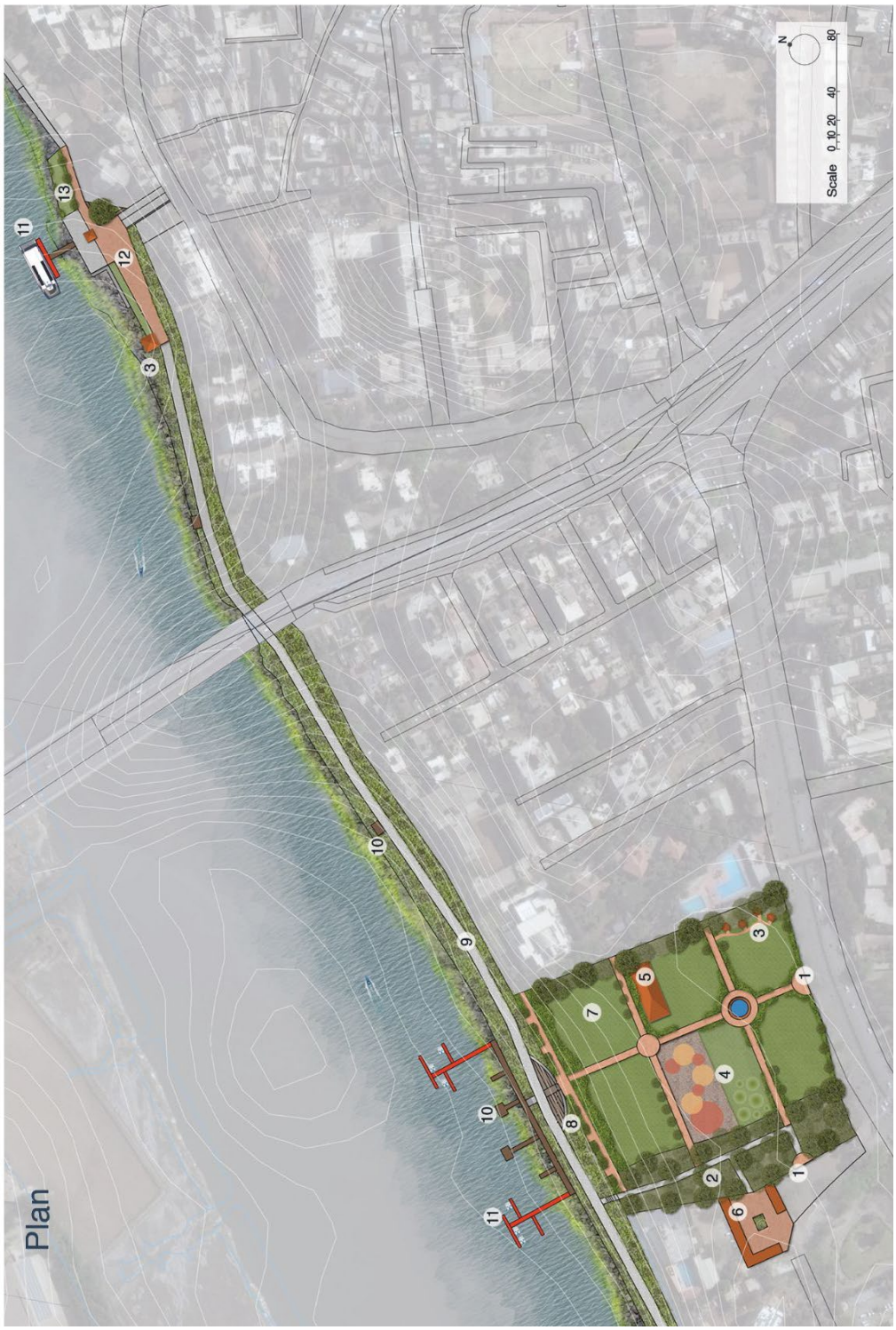

Fig 21 Prototype Site master plan

The central axis of the park is accompanied by low heighted shrubs that eventually rise into tall plants. This allows for visual connectivity with the river while being on the main streets of the city. The entrance plaza receives public from main road and parking. It reduces the crowd influx at roads and sidewalks.

Fig 22 Biodiversity patch and walkway

The entrance plaza from the parking lot leads you into the biodiversity patch. Instead of planned planting schemes, the character of these walks is more Naturalistic to attract native biodiversity. A similar kind of Natural landscape planting aligns to another side of the park as well.

Fig 23 Gazebo, Child Play area and Pavillion

As one enters from the main road, it leads to two segments of green open spaces. Club gatherings like senior citizen clubs and laughter clubs can be held here. After an energizing session, they can relax and socialize in a gazebo surrounded by Natural landscapes. The middle segments of the park are a safe child play area and a multipurpose pavilion which one can use for yoga and meditation. The play area ensures climate resilient and safe materials.

Fig 24 Food court

The middle segment also leads to the food court area. During monsoon season, The sloping roofs of the food court can direct runoff into the stormwater garden and the water can be used for park needs. During summer and winter season, it could provide shade or convert into an intimate food court experience with string lights

Fig 25 Multipurpose lawn, Amphitheatre and Riverfront walk

Moving towards the riverfront, is a multipurpose lawn which can be used for planned public gatherings, flea markets or is a great spot for picnic. There is a mini riverfront walk by the multipurpose lawn accompanied by pockets where one can simply hangout with a view of the river. This leads to the main riverfront walk passing by a mini amphitheatre overlooking the river. This amphitheatre would enhance the experience of being with the river and also add to a place for socializing.

Fig 26. Deck and Water activities

Further, multiple decks offer a great place to hangout and enjoy the riverfront. The floating decks can be adjusted according to water levels. Here, the mud is overlaid with a porous filtration layer of rocks and native wetland planting material to overcome pungent smell and brown landscape.

In terms of water activities, the park is restricted to smaller water activities like kayaking, paddle boarding and boating, whereas large scale water activities like water, taxi, and floating restaurants are moved to the port to ease water transportation and direct traffic.

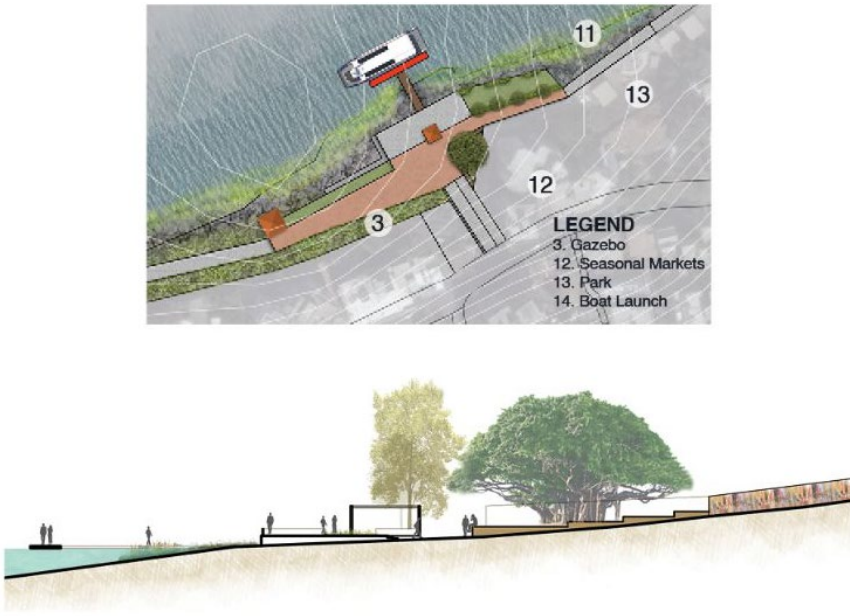

Fig 27. Port area site design

Walking along the riverfront with occasional pocket decks, one arrives at the port. As the site lies in a highly dense office area, cars are parked all over the place and is a major safety threat for pedestrians and bikers. So the parking is restricted until a certain limit. The change in material indicates a transition in space and being mindful of the pedestrians.

Moreover, The site provides a place for seasonal markets, a park where people from surrounding office areas can have lunch and take a break and relax. And from there people can hop onto the cruise restaurant for a lovely sunset dinner.

Fig 28. Sections

The modules from prototype site design like biodiversity patch, children play area, gazebo, food court, socializing decks can be referenced and used in further planning and design of the Tapi riverfront.

Phasing

Phase 1: Site analysis, Land Reclamation, efforts to demolish surface dam and construct sub-surface dam, dividing the project into 10km sections for efficient project management, Tapi cleaning project, development of river Tapi cell

Phase 2: Preparing the site in section 1 for laying groundwork, foundation construction, earthwork and planting schemes as required. Following the same process for remaining sections. Estuary landfill dredging

Phase 3: construction of Architectural buildings, amenities and utilities, planting schemes as required at this stage.

Phase 4: Partial opening to the public, planned seasonal markets, Completion of subsurface dam

Phase 5: Completion of Tapi riverfront and open to public

CHAPTER 6

CONCLUSION

An environmentally efficient riverfront does not only focus on traditional space making aspects of site design but focuses on the ecological, environmental and cultural systems of the river and the city, ensuring a safe interaction of mankind with the river and natural ecosystems. The design approach in this thesis also centers community participation and engagement during the process.

To rejuvenate river Tapi in parts or as a whole, a generic three step process can be followed; Acknowledge, Adapt and Act

Fig 29.1 Conclusion; Acknowledge

Acknowledge,

All the issues from xs to xxxl like, Existing conditions, Mistakes made in the past, Environmental impacts, Community concerns

Adapt,

To the Nature and systems that already exists like native plants and biodiversity, to the community usage, to the culture

Fig 29.2 Conclusion; Adapt

Act,

Design with all the considerations by means of integrating varied systems that we acknowledged and adapted to.

Fig 29.3 Conclusion; Act

Instead of designing with a traditional space making approach without considering the health of river tapi, An ecological, communal and economic centric approach will rejuvenate the city's greatest amenity, River Tapi.

BIBLIOGRAPHY

"20 Animal Species,16 Plant Species in Endangered Category in Gujarat." DeshGujarat., last modified -05-09T17:35:32+05:30, accessed Jun 12, 2021, https://www.deshgujarat.com/2016/05/09/20-animal-species16-plant-species-in-endangered-category-in-gujarat/.

"Activists Up Ante Against SMC HQ at Chowpaty Garden | Surat News - Times of India." The Times of India., accessed Jun 13, 2021, https://timesofindia.indiatimes.com/city/surat/activists-up-ante-against-smc-hq-at-chowpaty-garden/articleshow/79817331.cms.

"Coronavirus Highlights the Need for Open Green Spaces in Cities - Stockholm Resilience Centre.", last modified -04-21, accessed May 4, 2020, https://www.stockholmresilience.org/research/research-news/2020-04-21-coronavirus-highlights-the-need-for-open-green-spaces-in-cities.html.

"Development Pushing Great Indian Bustard into Pakistan | Ahmedabad News - Times of India." The Times of India., accessed Nov 9, 2020, https://timesofindia.indiatimes.com/city/ahmedabad/development-pushing-gibs-into-pakistan/articleshow/72323617.cms.

"Heritage of Surat Ovara Ghats.", accessed Jun 10, 2021, http://www.welovesurat.com/visit/heritage-of-surat-ovara-ghats.html.

Modeling Cities on Ecosystems CHAPTER 5 PRINCIPLE 5 Build on the Characteristics of Ecosystems in the Develop- Ment and Nurturing of Healthy and Sustainable Cities d.

"NGT Orders 5-Member Committee for Tapi River Restoration | Surat News - Times of India." The Times of India., accessed May 8, 2020, https://timesofindia.indiatimes.com/city/surat/ngt-orders-5-member-committee-for-tapi-river-restoration/articleshow/68225503.cms.

Opinion: In a Pandemic, we Need Green Spaces More than Ever f. Ensia. https://ensia.com/voices/pandemic-green-space/.

"Public Survey Responses." Google Form., https://docs.google.com/forms/d/1j1XqndMzYqYdekXdonRSwBmcXLhN1LlH3q6MMRDL1cg/edit#responses.

Six Ways Urban Spaces may Change because of Coronavirus 2020b. Boston Magazine. https://www.bostonmagazine.com/property/2020/04/30/urban-spaces-coronavirus/.

"Surat to be India's First 'Eco City' | Surat News - Times of India." The Times of India., accessed Nov 8, 2020, https://timesofindia.indiatimes.com/city/surat/Surat-to-be-Indias-first-Eco-City/articleshow/13678162.cms.

Urban Ecological Systems i.

ARUP Foundation. "Understanding the City Resilience Index - Arup.", accessed May 8, 2020, https://www.arup.com/en/projects/city-resilience-index.

Dahiya, Bharat and Thomas Stellmach. *Sustainable Urbanization in Asia*. https://www.academia.edu/2450645/Sustainable_Urbanization_in_Asia.

Gray, Christopher. "From Emergence to Divergence: Modes of Landscape Urbanism." . https://www.academia.edu/3025113/From_emergence_to_divergence_modes_of_landscape_urbanism.

Kordy, Ahmed El, Hesham Sobh, and Amira Mostafa. 2016. "The Problem of Applying Sustainability Ideas in Urban Landscape in Developing Countries." *Procedia Environmental Sciences* 34: 36-48. doi:10.1016/j.proenv.2016.04.007. http://www.sciencedirect.com/science/article/pii/S1878029616300299.

Nawre, Alpa. 2018. "Between Community and Culture: The Criticality of Landscape Infrastructure Reuse in India." *Journal of Landscape Architecture* 13 (3): 54-63. doi:10.1080/18626033.2018.1589141. https://doi.org/10.1080/18626033.2018.1589141.

Paul, Michael J. and Judy L. Meyer. *Streams in the Urban Landscape*.

Paul, Rahul. "Landscape Urbanism - an Introduction." . https://www.academia.edu/2045163/Landscape_Urbanism_-_An_Introduction.

Polsani, Pithamber. "Living Elsewhere: Aesthetics and Anxieties of New Urbanism in India." . https://www.academia.edu/38887426/Living_Elsewhere_Aesthetics_and_Anxieties_of_New_Urbanism_in_India.

Shannon, Kelly. "Traditions of Landscape Urbanism." *Topos 71, Pp. 62-67*. https://www.academia.edu/38884536/Traditions_of_Landscape_Urbanism.

Steiner, Frederick. 2011. "Landscape Ecological Urbanism: Origins and Trajectories." *Landscape and Urban Planning* 100 (4): 333-337. doi:10.1016/j.landurbplan.2011.01.020. http://dx.doi.org/10.1016/j.landurbplan.2011.01.020.

Waldheim Charles. 2016. *Landscape Urbanism Reader* Princeton University Press.